

FORM PTO-1390  
(REV 11-98)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

**TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371**

6224/JCK

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

**09/355987**

INTERNATIONAL APPLICATION NO.

PCT/AU98/00115

INTERNATIONAL FILING DATE

February 24, 1998

PRIORITY DATE CLAIMED

February 24, 1997

TITLE OF INVENTION  
Foundry Alloy

APPLICANT(S) FOR DO/EO/US

Joseph Giovanni BARRESI, Malcolm James COUPER, David Henry ST. JOHN, Geoffrey Alan

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information: EDWARD S a  
Hao WANG

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
  - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☒ has been transmitted by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ have been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

**Items 11. to 16. below concern document(s) or information included:**

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.  
☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:  
Notice of Correspondence Address and Filing Without Declaration

514 Rec'd PCT/PTO 24 AUG 1999

U.S. APPLICATION NO. (if known) <b>09/355987</b>		INTERNATIONAL APPLICATION NO. <b>PCT/AU98/00115</b>		ATTORNEY'S DOCKET NUMBER <b>6224/JCK</b>																																																																							
17. <input checked="" type="checkbox"/> The following fees are submitted: <b>BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5)):</b> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ..... <b>\$970.00</b> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... <b>\$840.00</b> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... <b>\$760.00</b> International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... <b>\$670.00</b> International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) ..... <b>\$96.00</b> <b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b>				<b>CALCULATIONS</b> PTO USE ONLY																																																																							
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<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">CLAIMS</th> <th style="width: 20%;">NUMBER FILED</th> <th style="width: 20%;">NUMBER EXTRA</th> <th style="width: 20%;">RATE</th> </tr> </thead> <tbody> <tr> <td>Total claims</td> <td>20 - 20 =</td> <td>0</td> <td>X \$18.00</td> </tr> <tr> <td>Independent claims</td> <td>2 - 3 =</td> <td>0</td> <td>X \$78.00</td> </tr> <tr> <td colspan="3">MULTIPLE DEPENDENT CLAIM(S) (if applicable)</td> <td>+ \$260.00</td> </tr> <tr> <td colspan="3"><b>TOTAL OF ABOVE CALCULATIONS =</b></td> <td><b>\$ 1,100.00</b></td> </tr> <tr> <td colspan="4">Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28).</td> <td>\$</td> <td></td> </tr> <tr> <td colspan="3"><b>SUBTOTAL =</b></td> <td><b>\$ 1,100.00</b></td> <td></td> <td></td> </tr> <tr> <td colspan="4">Processing fee of <b>\$130.00</b> for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).</td> <td>\$</td> <td></td> </tr> <tr> <td colspan="3"><b>TOTAL NATIONAL FEE =</b></td> <td><b>\$1,100.00</b></td> <td></td> <td></td> </tr> <tr> <td colspan="4">Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). <b>\$40.00</b> per property</td> <td>+</td> <td>\$</td> </tr> <tr> <td colspan="3"><b>TOTAL FEES ENCLOSED =</b></td> <td><b>\$ 1,100.00</b></td> <td></td> <td></td> </tr> <tr> <td colspan="4" rowspan="2"></td> <td style="text-align: right;">Amount to be:</td> <td>\$</td> </tr> <tr> <td style="text-align: right;">refunded</td> <td>\$</td> </tr> <tr> <td colspan="4" rowspan="2"></td> <td style="text-align: right;">charged</td> <td>\$</td> </tr> <tr> <td></td> <td></td> </tr> </tbody></table>				CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	Total claims	20 - 20 =	0	X \$18.00	Independent claims	2 - 3 =	0	X \$78.00	MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$260.00	<b>TOTAL OF ABOVE CALCULATIONS =</b>			<b>\$ 1,100.00</b>	Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28).				\$		<b>SUBTOTAL =</b>			<b>\$ 1,100.00</b>			Processing fee of <b>\$130.00</b> for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$		<b>TOTAL NATIONAL FEE =</b>			<b>\$1,100.00</b>			Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). <b>\$40.00</b> per property				+	\$	<b>TOTAL FEES ENCLOSED =</b>			<b>\$ 1,100.00</b>							Amount to be:	\$	refunded	\$					charged	\$		
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a. ☒ A check in the amount of \$ 1,100.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. \_\_\_\_\_ in the amount of \$ \_\_\_\_\_ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0610. A duplicate copy of this sheet is enclosed.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

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 John C. Kerins  
 NAME  
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 32,421  
 REGISTRATION NUMBER

Docket: 6224

IN THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)

Applicant: Joseph Giovanni BARRESI et al.

International  
Application No.: PCT/AU98/00115

International  
Filing Date: February 24, 1998

U.S. Serial No.:

U.S. Filing Date: August 24, 1999

For: Foundry Alloy

Falls Church, Virginia  
August 24, 1999

**PRELIMINARY AMENDMENT**

Assistant Commissioner of Patents  
Washington, D.C. 20231

Sir:

This Preliminary Amendment is being filed contemporaneously with the filing of papers under 35 U.S.C. §371 directed to the entry into U.S. national stage processing of PCT Application No. PCT/AU98/00115. Please amend the application as indicated below.

**IN THE CLAIMS:**

Please amend the following claims:

1. (Amended) An alloy which comprises:
  - Si : 6.5 - 7.5 wt%
  - Fe : up to 0.20 wt%

4 Cu : up to 0.05 wt%  
 5 Mn : up to 0.05 wt%  
 6 Mg : 0.35 to 0.50 wt%  
 7 Zn : up to 0.05 wt%  
 8 Ti : up to 0.20 wt%  
 9 [Balance :] and the balance Al and other components, [the]  
 10 wherein said other components comprise a total of not more than 0.15 wt% of  
 11 said alloy and any single component of [the] said other components does not  
 12 exceed 0.05 wt% of said alloy, the alloy having a microstructure which  
 13 includes a primary aluminum-containing matrix and one or more iron-  
 14 containing phases dispersed in the matrix, and wherein the sole or  
 15 predominant iron-containing phase is  $\beta$  phase that has formed as a  
 16 transformation product of  $\pi$  phase.

In Claim 4, line 1, delete "any one of the preceding claims", and  
 insert --Claim 1--.

1 5. (Amended) A method for manufacturing an alloy article  
 2 [which comprises] comprising the steps of:  
 3 (a) providing a melt having a composition of:  
 4 Si : 6.5 - 7.5 wt%  
 5 Fe : up to 0.20 wt%  
 6 Cu : up to 0.05 wt%

7 Mn: up to 0.05 wt%  
 8 Mg : 0.35 to 0.50 wt%  
 9 Zn : up to 0.05 wt%  
 10 Ti : up to 0.20 wt%  
 11 [Balance :] and the balance Al and other components, [the]  
 12 said other components comprising a total of not more than 0.15 wt% of said  
 13 alloy and any single component of [the] said other components not exceeding  
 14 0.05 wt% of said alloy,  
 15 (b) casting said melt and solidifying a casting at a cooling rate  
 16 that produces a microstructure of an aluminum-containing matrix and  $\pi$  and  $\beta$   
 17 iron-containing phases dispersed in the matrix;  
 18 (c) solution heat treating the casting to at least partially  
 19 transform  $\pi$  phase to  $\beta$  phase; and  
 20 (d ) quenching the casting to form the alloy article.

In Claim 7, line 1, delete "or claim 6".

In Claim 10, line 1, delete "or claim 6".

In Claim 11, lines 1 and 2, delete "any one of claims 5 to 10",  
 and replace with --Claim 5--.

In Claim 12, lines 1 and 2, delete "any one of claims 5 to 11",  
 and replace with --Claim 5--.

In Claim 13, lines 1 and 2, delete "any one of claims 5 to 12",  
 and replace with --Claim 5--.

In Claim 13, line 2, delete "includes" and replace with  
--including--.

Please add the following new claims:

1                   --15. The alloy defined in claim 3, wherein the Mg content of the  
2 alloy is 0.40-0.45 wt%.

1                   16. The method defined in claim 6, wherein the sole or  
2 predominant iron-containing phase in the alloy article is  $\beta$  phase.

1                   17. The method defined in claim 6, wherein the step of  
2 solidifying the casting produces iron-containing phases that include a  
3 substantial proportion of  $\pi$  phase and the subsequent solution heat treatment  
4 step is effective to convert a majority of the  $\pi$  phase to  $\beta$  phase to give a  
5 microstructure in the alloy article that includes iron-containing phases which  
6 are predominantly  $\beta$  phase.

1                   18. The method defined in claim 10, wherein, prior to casting,  
2 the melt is at a temperature above the liquidus temperature of the alloy.

1                   19. The method defined in claim 18, wherein the quenching  
2 step is in hot water having a temperature of 70-80°C.

- 1                   20. The method defined in claim 19, further including an ageing  
2                   heat treatment of the alloy article.--

**REMARKS**


Favorable consideration of the present application is respectfully requested.

The changes made in the claims by this Preliminary Amendment are to place the claims in a form more consistent with U.S. patent practice, including the elimination of multiple dependencies from the claims.

Early and favorable action on the merits of this application is earnestly solicited.

Respectfully,

KERKAM, STOWELL, KONDRACKI  
& CLARKE, P.C.

By:   
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~~FOUNDRIY ALLOY~~

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10 The present invention relates to an improved foundry alloy and to a method of producing an improved foundry alloy. In particular, the improved foundry alloy is an aluminium-based alloy.

15 Primary metal based foundry alloys are largely used for structural or safety type applications where there is a requirement for high and consistent mechanical properties. The majority of components made from aluminium foundry alloys are made from hypoeutectic aluminium-silicon-magnesium alloys containing a nominal silicon level  
20 of 7% by weight (601 and 603 designations). In simple terms these alloys are a composite of hard, discontinuous silicon particles and large, brittle iron intermetallics embedded in a ductile aluminium matrix.

25 There are three registered Australian compositions for strontium-modified aluminium - 7% silicon alloys. These are given in Table 1. The magnesium content of the alloys covers the range 0.25 to 0.4 wt% (601 alloys) and 0.45 to 0.7 wt% (603 alloys). The addition of  
30 magnesium allows castings to be heat treated to form magnesium silicide precipitates. These harden the matrix of the alloy to obtain the desired combination of strength and ductility.

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Table 1. Registered alloy composition for strontium modified 601/603 type foundry alloys

Alloy Code	Si	Fe	Cu	Mn	Mg	Zn	Ti	Other Each	Other Total	Al
AC601	6.5-7.5	0.20	0.05	0.05	0.30-0.40	0.05	0.20	0.05	0.15	Rem
CC601	6.5-7.5	0.20	0.05	0.05	0.25-0.35	0.05	0.20	0.05	0.15	Rem
AC603	6.5-7.5	0.15	0.05	0.03	0.45-0.7	0.05	0.20	0.05	0.15	Rem

10 4 Compositions in weight percent. Compositions indicate a maximum unless a range is given

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The main impurity found in these alloys is iron. The iron solidifies from the eutectic liquid into a number of brittle phases.

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The two major iron-containing phases found in these alloys are the  $\pi$  phase ( $\text{Al}_3\text{Si}_2\text{Mg}_3\text{Fe}$ ) which is the predominant phase formed in high Mg content alloys and the  $\beta$  phase ( $\text{Al}_3\text{SiFe}$ ) which forms in low magnesium content alloys. The  $\pi$  phase forms into a script morphology while the  $\beta$  phase is less voluminous and forms into acicular plates. Both phases are detrimental to mechanical properties. High Mg contents (ie greater than 0.6 wt% Mg) are desirable to provide higher strength, but the presence of  $\pi$  phase at high Mg contents causes the ductility of the alloys to unfavourably decrease.

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Conventional theories on the micro-mechanics of failure of premodified 601 and 603 alloys state that the iron rich intermetallic phases are critical in determining the fracture toughness as the silicon particles are small and round. Increases in the magnesium content of these alloys increase the amount of the  $\pi$  phase, which has a negative impact on the ductile properties of the alloys.

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Further, as some magnesium is contained in the  $\pi$  phase, the maximum volume fraction of magnesium silicide precipitates cannot be obtained. Thus, the alloys do not achieve the maximum possible strength consistent with their magnesium content.

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Also, as the magnesium content of an alloy increases the magnesium content of the  $\pi$  phase may change leading to even greater volume fractions of the phase for a given Fe content.

It is thus concluded that the overall quality of

an alloy, as given by the quality index, decreases as increasing volume fractions of the  $\pi$  phase forms at increased magnesium contents. The quality index is given by the formula:

5

$$Q.I. = UTS + 150 \log_{10} E$$

where:

10

Q.I. = Quality Index (Mpa)

UTS = Ultimate Tensile Strength (Mpa)

E = Elongation at Fracture (%)

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Attempts have been made to eliminate the  $\pi$  phase and thus remove its detrimental impact on mechanical properties.

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By way of example, beryllium additions can be used to precipitate the iron impurity as part of the  $BeSiFe_3Al_3$  phase. This beryllium-containing phase forms in preference to the  $\pi$  phase, leading to alloys with improved mechanical properties. Unfortunately, there are serious health hazards associated with using beryllium. Consequently, beryllium modification is not widely practised and the deleterious effect of the  $\pi$  phase on alloy quality remains.

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Other attempts to modify the iron-containing phases, for example by using Mn, have been tried in secondary alloys but have not been used in primary alloys.

It is an object of the present invention to provide an improved foundry alloy.

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In accordance with the present invention this object is achieved by an alloy having a microstructure in which  $\beta$  phase that forms during heat treatment as a transformation product of  $\pi$  phase is the sole or

predominant iron-containing phase. The reduction in  $\pi$  phase results in an improvement in ductility. Moreover, the  $\beta$  phase that forms as the transformation product has a fine structure that improves ductility. Further, the reduction in  $\pi$  phase means that there are higher levels of Mg in solution which are available for precipitation during ageing to improve the strength of the alloy.

In a first aspect, the present invention provides an alloy which comprises:

Si	:	6.5 - 7.5 wt%
Fe	:	up to 0.20 wt%
Cu	:	up to 0.05 wt%
Mn	:	up to 0.05 wt%
Mg	:	0.35 to 0.50 wt%
Zn	:	up to 0.05 wt%
Ti	:	up to 0.20 wt%

Balance : Al and other components, the other components comprise a total of not more than 0.15 wt% and any single component of the other components does not exceed 0.05 wt%, the alloy having a microstructure which includes a primary aluminium-containing matrix and one or more iron-containing phases dispersed in the matrix, and wherein the sole or predominant iron-containing phase is  $\beta$  phase that formed as a transformation product of  $\pi$  phase.

It is preferred that the dendrite arm spacing of the matrix be 10-45 $\mu$ m.

Where there is more than one iron-containing phase, preferably the iron-containing phases also include  $\pi$  phase.

Preferably, the iron-containing phases include  $\pi$  phase in an amount up to 30 vol% of the iron-containing

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phases. The amount of  $\pi$  phase may be higher if the Mg content is in the upper end of the range.

The Mg content of the alloy is preferably 0.40-0.45 wt%. Within this Mg range, the alloy is a variant of the 601/603 type foundry alloy. It has been realised by the applicant that close control of the magnesium content to be between 0.40 and 0.45 wt% can lead to an increase in alloy quality and improved mechanical properties. In particular, when the magnesium content is controlled to be between 0.40 and 0.45 wt% the variation in alloy quality for a small change in magnesium level is minimal. Thus, the consistency in the mechanical properties of the alloy is maximised.

The present invention also provides a method for manufacturing an alloy article.

In a second aspect, the present invention provides a method for manufacturing an alloy article which comprises:

(a) providing a melt having a composition of:

Si	:	6.5 - 7.5 wt%
Fe	:	up to 0.20 wt%
Cu	:	up to 0.05 wt%
Mn	:	up to 0.05 wt%
Mg	:	0.35 to 0.50 wt%
Zn	:	up to 0.05 wt%
Ti	:	up to 0.20 wt%

Balance : Al and other components, the other components comprising a total of not more than 0.15wt% and any single component of the other components not exceeding 0.05 wt%,

(b) casting said melt and solidifying a casting

at a cooling rate that produces a microstructure of an aluminium-containing matrix and  $\pi$  and  $\beta$  iron-containing phases dispersed in the matrix;

5

(c) solution heat treating the casting to at least partially transform  $\pi$  phase to  $\beta$  phase; and

10

(d) quenching the casting to form the alloy article.

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It is preferred that the cooling rate be sufficient to produce a dendrite arm spacing in the matrix in the casting of 10-45 $\mu$ m.

Preferably, the sole or predominant iron-containing phase in the alloy article is  $\beta$  phase.

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Where there is more than one iron-containing phase in the alloy article, preferably the iron-containing phases also include  $\pi$  phase. More preferably, the iron-containing phases in the alloy article include  $\pi$  phase in an amount of up to 30 vol% of the iron-containing phases. Higher levels of  $\pi$  phase may be present if the Mg content is at the upper end of the above range.

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It is preferred that the step of solidifying the casting produces iron-containing phases that include a substantial proportion of the  $\pi$  phase and the subsequent solution heat treatment step is effective to convert at least some and preferably a majority of the  $\pi$  phase to  $\beta$  phase to give a microstructure in the alloy article that includes iron-containing phases which are predominantly  $\beta$  phase.

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The melt prior to casting may be at a temperature

above the liquidus temperature of the alloy, with the melt having sufficient superheat to fill the mould, that is at a temperature of 680-720°C.

5           The solution treatment of the casting may be carried out at any suitable temperature and for any suitable time to achieve a desired level of transformation of  $\pi$  phase  $\beta$  phase. In any given situation, the selection of the parameters of temperature and time will depend on  
10 variables, such as the concentrations of magnesium and other elements in the casting. By way of example, the applicant has found that for castings having a Mg concentration of 0.5 wt%, solution treatment at 540°C for 2 or more hours produced desired levels of transformation of  
15  $\pi$  to  $\beta$  phase

After the solution heat treatment, the casting is preferably quenched, more preferably quenched in hot water, such as hot water having a temperature of 70-80°C.

20           After quenching, the alloy article is cooled to room temperature and optionally subjected to an ageing heat treatment.

25           The ageing heat treatment may include heating the alloy article to a temperature of 140-170°C and holding at that temperature for 1-10 hours. After the ageing heat treatment, the alloy article may be air cooled to room temperature.

30           Results to support the present invention are given in Figure 1, in which plots of typical response surfaces derived from experimentally determined quality index data are shown. The three surfaces correspond to  
35 alloys that were cast at different solidification rates and thereafter solution treated and aged. Solidification rate is commonly measured by the as-cast dendrite cell size or

secondary dendrite arm spacing (DAS) but other methods exist. The results here use secondary dendrite arm spacing to indicate solidification rate, with a small dendrite arm spacing corresponding to a high solidification rate.

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It can be seen from Figure 1 that:

- (i) at the high solidification rate ( $\approx 20\mu\text{m}$  DAS) the alloy quality peaks at a magnesium level of 0.45-0.50 weight percent;
- (ii) at the intermediate solidification rate ( $\approx 40\mu\text{m}$  DAS) the quality peaks at a magnesium level of 0.35-0.40 weight percent; and
- (iii) at the low solidification rate ( $\approx 60\mu\text{m}$  DAS) the quality maximum occurs at a magnesium level of 0.25-0.30 weight percent.

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Further, it can be seen from Figure 1 that the magnesium level for the peak quality is independent of the iron level for the iron levels examined. Also, the rate of change of the response surfaces with magnesium is least near the peak in quality index. This means that the alloys at the peak are less sensitive to changes in magnesium than other alloys. The peak quality from Figure 1 corresponds well with microstructural evidence for small amounts of  $\pi$  phase in the alloy. By increasing the magnesium content of the alloy, it can be seen that in some circumstances improved quality results.

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It should be noted that the present invention works best with those casting designs or casting methods which produce high solidification rates ( $\leq 45\mu\text{m}$  DAS), such as permanent mould, mould chill methods with sand, and squeeze casting. Indeed, the trend in the automotive industry is to move away from thick section, low

solidification rate (high DAS) castings towards lightweight castings with thinner sections and higher solidification rates (low DAS).

5           The common belief prior to the present invention was that low magnesium levels produce high quality castings. The results shown here confirm this to be true at low solidification rates (Figure 1c). However, at higher solidification rates, the magnesium contents covered  
10 by this invention show, surprisingly, improved alloy quality and therefore improved mechanical properties.

15           Figures 2(a) to 2(c) are photomicrographs of hypoeutectic alloys having a Si concentration of 7 wt% and various Mg concentrations which were cast at the same solidification rate (60µm DAS), solution treated, and aged. Figure 2(d) is a photomicrograph of the as-cast alloy of Figure 2(c), ie before heat treatment.

20           In Figure 2(a), the Mg content of the alloy is higher than the Mg content of the alloy of the present invention. The main phases shown in Figure 2(a) are spheroidal silicon-containing phase and the iron-containing  $\pi$  phase.

25           Figure 2(b) shows the microstructure of an alloy containing less Mg than the alloy of the present invention. The phases present include spheroidal silicon-containing phase and iron-containing  $\beta$  phase. The  $\beta$  phase is present  
30 as structures of high aspect ratio dispersed throughout the matrix.

35           Figure 2(c) shows the microstructure of an alloy of the present invention. The phases include spheroidal silicon-containing phases, a small amount of  $\pi$  phase and  $\beta$  phase. The  $\beta$  phase is present as structures of high aspect ratio clumped together. This is consistent with the  $\beta$

phase being formed by transformation of  $\pi$  phase during heat treatment.

Figure 2(d) shows that prior to heat treatment the as-cast alloy of Figure 2(c) had regions of  $\pi$  phase. As is evident from Figure 2(c) these  $\pi$  phase regions were largely transformed to  $\beta$  phase during heat treatment.

The drive for alloys with improved mechanical properties stems from the major restraint that mechanical properties place on the design of the casting, or even if a cast alloy can be used to manufacture a certain component. The thickness of critical sections needs to be sufficiently large that the cast component can operate without failure. Mechanical properties of the alloys therefore limit the minimum weight of a cast component. Further, the thickness of sections of a casting will determine the time required for the casting to solidify. For certain casting methods, such as low pressure die casting, the production rate is often determined by the solidification rate as the casting machine is tied up until the casting has fully solidified. Finally, the solution treatment, quench rate and ageing treatment of a cast component may be tailored to its design so as not to induce unnecessarily high residual stresses. High residual stresses can cause distortion of the component requiring additional machining. The mechanical properties of the base alloy therefore affect all stages of manufacturing from design, to casting the component, heat treatment, machining, final weight and production rate.

The present invention therefore has the following more specific applications:

- (i) New markets for aluminium-7% silicon foundry alloys. Cast alloys generally have inferior mechanical properties but lower manufacturing costs compared to similar

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components made from wrought alloys. The high mechanical property requirements of some components necessitates the use of wrought alloys. The achievement of alloys of the present invention which have higher and more consistent mechanical properties than conventional alloys may allow the use of the alloy of the present invention to replace wrought alloys, or other cast alloys, for some components.

(ii) Cast components with thinner sections and lower total weight. The improved and more consistent mechanical properties of the alloy of the present invention allows components with thinner sections to be designed and cast. Despite their thinner sections, these components can still operate without failure and will have a lower total weight.

(iii) Cast components with an improved production rate. Castings with thinner sections may require less time to solidify. Production equipment will then be tied up for less time waiting for a component to solidify. The production rate is thus increased.

(iv) Cast components with refined iron and silicon intermetallic phases. The solidification time of a casting strongly determines the coarseness of the microstructure. Components with thinner sections and therefore higher solidification rates (and lower solidification times) will have a more refined microstructure. This refining of the microstructure will provide

additional improvements to the mechanical properties of a casting, independent of the use of a superior alloy.

- 5 (v) Cast components with reduced heat treatment time. Castings with thinner sections require less time to homogenise. Further, the time required for the casting to reach the solution treatment temperature or ageing
- 10 temperature will be less. This also benefits the production rate of components.
- (vi) Cast components with increased quench rate. Thinner castings may quench more rapidly.
- 15 This may lead to improved mechanical properties as it suppresses the formation of magnesium-silicide precipitates during cooling. These improved properties are independent of any refinement of the
- 20 microstructure or the use of a superior alloy.

It will be appreciated that the invention described herein is susceptible to variation and

25 modifications other than those specifically described. It is to be understood that the invention encompasses all such variations and modifications that fall within its spirit and scope.

## CLAIMS:

1. An alloy which comprises:

Si : 6.5 - 7.5 wt%  
Fe : up to 0.20 wt%  
Cu : up to 0.05 wt%  
Mn : up to 0.05 wt%  
Mg : 0.35 to 0.50 wt%  
Zn : up to 0.05 wt%  
Ti : up to 0.20 wt%

Balance : Al and other components, the other components comprise a total of not more than 0.15 wt% and any single component of the other components does not exceed 0.05 wt%, the alloy having a microstructure which includes a primary aluminium-containing matrix and one or more iron-containing phases dispersed in the matrix, and wherein the sole or predominant iron-containing phase is  $\beta$  phase that formed as a transformation product of  $\pi$  phase.

2. The alloy defined in claim 1, wherein when the alloy includes more than one iron-containing phase, the iron-containing phases also include  $\pi$  phase.

3. The alloy defined in claim 2, wherein the  $\pi$  phase is up to 30 vol% of the iron-containing phases.

4. The alloy defined in any one of the preceding claims, wherein the Mg content of the alloy is 0.40-0.45 wt%.

5. A method for manufacturing an alloy article which comprises:

(a) providing a melt having a composition of:

Si : 6.5 - 7.5 wt%  
Fe : up to 0.20 wt%  
Cu : up to 0.05 wt%  
Mn : up to 0.05 wt%  
Mg : 0.35 to 0.50 wt%  
Zn : up to 0.05 wt%  
Ti : up to 0.20 wt%

Balance : Al and other components, the other components comprising a total of not more than 0.15wt% and any single component of the other components not exceeding 0.05 wt%,

(b) casting said melt and solidifying a casting at a cooling rate that produces a microstructure of an aluminium-containing matrix and  $\pi$  and  $\beta$  iron-containing phases dispersed in the matrix;

(c) solution heat treating the casting to at least partially transform  $\pi$  phase to  $\beta$  phase; and

(d) quenching the casting to form the alloy article.

6. The method defined in claim 5, wherein the cooling rate is sufficient to produce a dendrite arm spacing in the matrix of between 10 and 45 $\mu$ m.

7. The method defined in claim 5 or claim 6, wherein the sole or predominant iron-containing phase in the alloy article is  $\beta$  phase.

8. The method defined in claim 5, wherein when the alloy includes more than one iron-containing phase in

the alloy article, the iron-containing phases also include  $\pi$  phase.

9. The method defined in claim 8, wherein the  $\pi$  phase is up to 30 vol% of the iron-containing phases.

10. The method defined in claim 5 or claim 6, wherein the step of solidifying the casting produces iron-containing phases that include a substantial proportion of  $\pi$  phase and the subsequent solution heat treatment step is effective to convert a majority of the  $\pi$  phase to  $\beta$  phase to give a microstructure in the alloy article that includes iron-containing phases which are predominantly  $\beta$  phase.

11. The method defined in any one of claims 5 to 10, wherein prior to casting the melt is at a temperature above the liquidus temperature of the alloy.

12. The method defined in any one of claims 5 to 11, wherein the quenching step is in hot water having a temperature of 70-80°C.

13. The method defined in any one of claims 5 to 12, further includes an ageing heat treatment of the alloy article.

14. The method defined in claim 13, wherein the ageing heat treatment includes heating the alloy article to a temperature of 140-170°C, holding the alloy article at that temperature for 1-10 hours, and air cooling the alloy article to room temperature.

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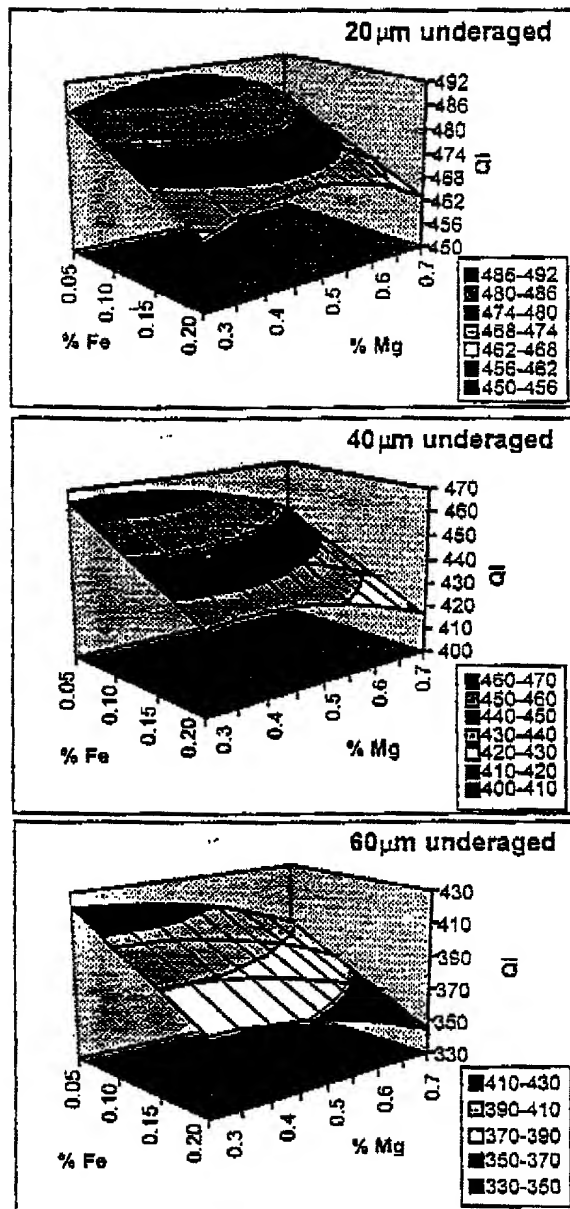


Figure 1

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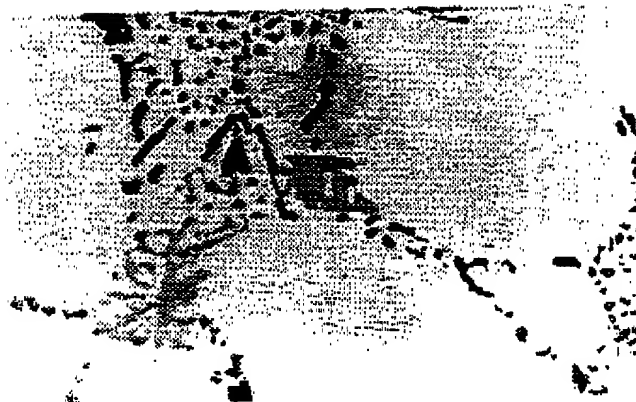


Figure 2 a Mag. X200



Figure 2 b Mag. X200



Figure 2 c Mag. X500

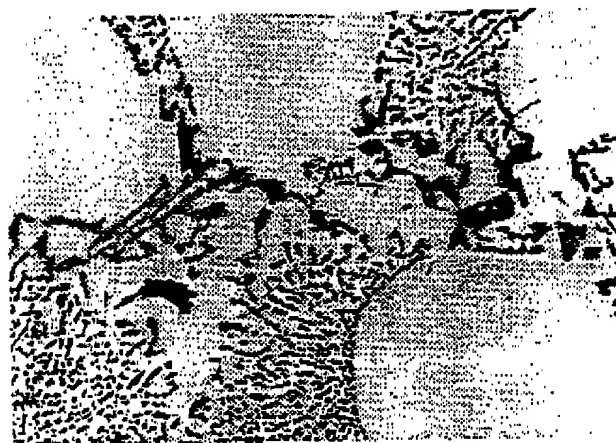


Figure 2 d Mag. X200

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<b>DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION</b> (37 CFR 1.63)	Attorney Docket Number	6224
	First Named Inventor	BARRESI et al.
	<b>COMPLETE IF KNOWN</b>	
	Application Number	09 / 355,987
	Filing Date	August 24, 1999
<input type="checkbox"/> Declaration Submitted with Initial Filing	OR	<input checked="" type="checkbox"/> Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)
	Group Art Unit	
Examiner Name		

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Foundry Alloy

☐ the specification of which (Title of the Invention)

☐ is attached hereto  
OR

☒ was filed on (MM/DD/YYYY) 08/24/1999 as United States Application Number or PCT International

Application Number 09/355,987 and was amended on (MM/DD/YYYY) 08/24/1999 (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(e) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached?	
PO 5268	Australia	02/24/1997	<input type="checkbox"/>	YES	NO
PCT/AU98/0015	Australia	02/24/1998	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	
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**DECLARATION — Utility or Design Patent Application**

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT International application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.55 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)
PCT/AU98/00115	02/24/1998	

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

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## DECLARATION

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 Supplemental Sheet  
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Name of Additional Joint Inventor, if any		<input type="checkbox"/> A petition has been filed for this unsigned inventor	
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Inventor's Signature	Date		
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Name of Additional Joint Inventor, if any		<input type="checkbox"/> A petition has been filed for this unsigned inventor	
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